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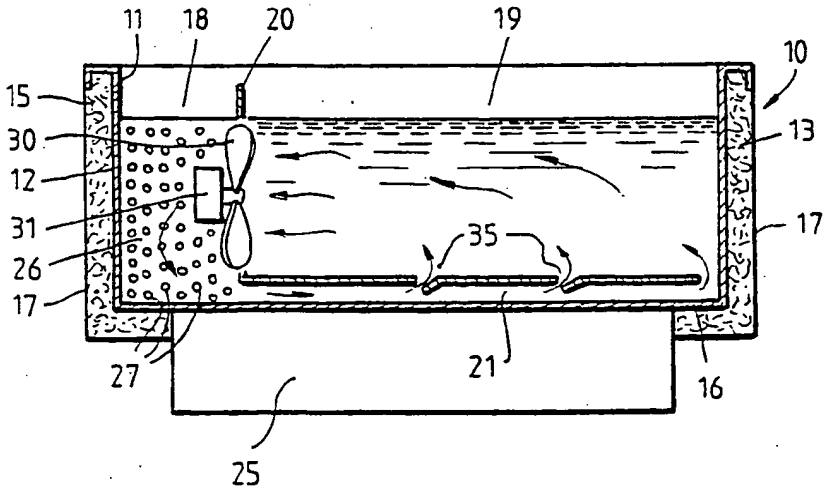
(54) Title: HIGH SPEED CHILLING



(57) Abstract

A method of rapidly chilling or freezing foodstuff in an open bath containing a liquid that is capable of being chilled, the liquid containing a suitable wetting agent, the method comprising the steps of: a) selecting a temperature for chilling a liquid, b) cooling the liquid to the selected temperature, c) selecting a rate of flow of chilled liquid, d) varying the speed of at least one electrically driven fan to ensure flow of liquid at the selected speed, e) selecting the time of immersion, f) immersing the foodstuff in the flow of chilled liquid at the selected speed and temperature, and g) removing the chilled/frozen foodstuff from the flow of chilled liquid after expiry of the preselected immersion time. Apparatus for rapidly chilling or freezing foodstuff comprising an open bath arranged to contain chilled liquid containing a suitable wetting agent, refrigeration means having chilling coils positioned in the open bath, means to immerse foodstuff into the bath, means to control the period of immersion, drive means positioned within the bath to, in use, cause controlled flow of liquid around the bath and past the chilling coils.

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Title

High Speed Chilling

Field of the Invention

This invention relates to high speed chilling and in particular relates to a method and apparatus for particularly, but not exclusively, rapid chilling or freezing of product in the form of foodstuffs.

Discussion of Prior Art

It is desirable to chill product to storage temperature as quickly as possible (i.e. fresh or frozen) to maintain original appearance, texture and flavour, also to reduce deterioration of the product and extend the storage or shelf life. Up till now this has been done by low temperature cool rooms or blast tunnels. Blast tunnels have a tendency to "burn" or remove moisture from the product, thus giving it a dried out or wrinkled appearance. Air chilling methods while removing moisture from the product also reduce the weight of the product.

In the applicant's earlier patent application

PCT/AU90/00362, there is disclosure of a small apparatus for rapid chilling of bottles and cans. In this application, liquid at freezing temperatures is circulated around bottles or cans that are placed in a storage vessel. An electric motor and agitator drives the liquid which is chilled by refrigeration coils which are coupled to a refrigeration circuit. The device of PCT/AU90/00362 is restricted in its size and range of application. The apparatus is not designed primarily as a freezing unit.

It is the object of this invention to provide apparatus which will rapidly chill or freeze using a wet chilling method - without any drying effect or subsequent weight loss.

Summary of the Invention

In accordance with one aspect of the present invention, there is provided a method of rapidly chilling or freezing foodstuff in an open bath containing a liquid that is capable of being chilled, the liquid containing a suitable wetting agent, the method comprising the steps of:

a) selecting a temperature for chilling a liquid,

b) cooling the liquid to the selected temperature,

c) selecting a rate of flow of chilled liquid,

d) varying the speed of at least one electrically driven fan to ensure flow of liquid at the selected speed,

e) selecting the time of immersion,

f) immersing the foodstuff in the flow of chilled liquid at the selected speed and temperature, and

g) removing the chilled/frozen foodstuff from the flow of chilled liquid after expiry of the preselected immersion time.

According to another aspect of the present invention there is provided apparatus for rapidly chilling or freezing foodstuff comprising an open bath arranged to contain chilled liquid containing a suitable wetting agent, refrigeration means having chilling coils positioned in the open bath,

means to immerse foodstuff into the bath, means to control the period of immersion, drive means positioned within the bath to, in use cause controlled flow of liquid around the bath and past the chilling coils.

Preferably, the solute is especially formulated and it is the balance of the flow rate of the solute circulated around the product, at the temperature selected that achieves the result. The product can either be fresh, unpacked and loose or packaged by a vacuum packaging method.

Discussion of the Drawings

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a side on view of one form of apparatus for chilling or freezing foodstuff, and

Figure 2 is a plan view of the apparatus shown in Figure 1,

Figure 3 is a circuit layout of a refrigeration condensing system that forms part of the apparatus, and

Figure 4 is a perspective view of an evaporator that forms part of the refrigeration system.

Description of the Preferred Embodiments

As shown in Figures 1 and 2, the apparatus for rapidly chilling or freezing foodstuff comprises a main frame 10 in the form of an open rectangular stainless steel bath 11 having side portions 12, 13, 14 and 15 and a base 16. The exterior of the bath 11 is clad in a suitable insulation 17 such as polystyrene. The tank is essentially divided into two main compartments namely, a chilling zone 18 and an immersion zone 19, the zones 17 and 18 being interconnected through a base mounted conduit 21. A circulation baffle 20 separates immersion zone 19 from the chilling zone 18 and conduit 21.

The apparatus comprises of a refrigeration condensing

set 25, which in the case of a smaller plant can be incorporated in the base of the frame 10. The refrigeration condensing set 25 shown in Figure 3 is of modular design allowing a wide variation in sizes of equipment from chilling systems that operate at a few grams/hr or large systems that chill at a few tonnes/hr. The refrigeration condensing set 25 comprises a compressor 40 driven by an electric motor 41. The compressor 40 is coupled to a discharge service valve 42 which is in turn coupled to a condenser 43 via a discharge line 44. The condenser 43 is coupled to a liquid receiver 45 which feeds a dehydrator 46 via a liquid line 47. The dehydrator 46 is coupled to an evaporator 48 via a thermostatic expansion valve (TX valve) 49. The TX valve is also coupled to the outlet (suction) line 50 of the evaporator 48 which line 50 feeds back to the compressor 40 via a metered flood accumulator 51 and suction service valve 52.

The evaporator 48 can comprise a single bank of coils 26 as shown in Figures 3 and 4 or can comprise two spaced banks 26 as shown in Figures 1 and 2. The coils 26 arranged in banks of parallel arrays 27 across the chilling zone 18. A metered flood accumulator 51 is used to control refrigerant flood back and to ensure oil return to the compressor 40. Without the protection of this accumulator, liquid refrigerant will occasionally flood back to the compressor 40 and flush oil out of the sump or damage the valves.

Unlike conventional chilling units it is a characteristic of this system to frequently flood back to the compressor 40. This feature is effected by a combination of the following variations, many of which do not constitute usual refrigeration practice:

a) The evaporator coils consist of several very short passes 55 to minimise pressure drop down to a maximum of 1 psig.

b) Each of these passes is fed individually through a distributor and equally sized feed capillaries 57.

c) Each pass is fed to a common header then to the metered flood accumulator 51 to control the flood back.

d) The TX valve 49 is set to 1.5°C, in comparison of a usual setting of about 7°C, super heat to ensure that the entire evaporator 48 is totally active at all times.

To achieve the rapid rate of heat exchange required it is essential to keep the pressure drop across the evaporator to a minimum by use of multi short passes and controlled feed tubes. This then allows for the 1.5°C super heat setting on the TX valve to utilise the evaporator to its maximum potential.

The term 'heat exchange' as used in describing this system embraces:

1) Refrigerant to evaporator,

2) Evaporator to solute, and

3) Solute to produce.

By adhering to the above design criteria an increase of condensing unit capacity in excess of 20% can be realised. This provides obvious environmental advantages and facilitates the use of physically smaller condensing units.

This condition exists because of the nature of the evaporator coils 26. Unlike conventional systems these coils 26 are designed to operate on an extremely low TX valve superheat setting combined with a minimal pressure drop across the coil. Unlike conventional refrigeration coils smaller diameter pipe is used for very short individual passes that are fed separately by matched capillary feeders. The efficiency of the coil is increased by decreasing the pressure drop. The tubes are cut to length and are sized internally to ensure uniformity of refrigerant flow.

As indicated in Figures 1 and 2 the evaporator coils 26 are mounted in the chilling zone 18 of the insulated

tank 11. Circulating fans 30 are fitted in the dividing panel 20 and driven by specially designed motors 31 which are immersed in the super chilled liquid. The tank 11 is filled with an anti-corrosive food grade glycol based solute which is formulated to resist freezing above -35° centigrade, and thus achieve this temperature without excessive thickening. A wetting agent is added to stop foaming at low temperatures and to "wet" the evaporator coils and product to be chilled. The wetting agent enhances the heat transfer rate in both areas to produce the rapid rate of chilling that can be achieved.

The solute is drawn from the immersion zone 18 by the circulating fans 30, forced through the coil banks 26, directed via louvres 35 in the base divider 20 around the product to be chilled and then recirculated again by the fans 30. The fans ensure the required circulation and agitation of the solute.

In operation, the refrigeration condensing set 25 super chills the banks of coils 26 so that the solute within the chilling zone is superchilled down to a temperature of about -35 degrees centigrade. The circulation fans 30 ensure that the super chilled solute is circulated throughout the tank and especially circulated within the immersion zone 18. The foodstuff is immersed into the immersion zone and rapidly frozen by the super chilled liquid.

To achieve optimum performance, it is essential during design to maintain close tolerances with relation to balance in the following areas:-

1) Compressor capacity control

A very close balance between condensing efficiency and evaporator requirement is essential. For example, if the condensing unit was 10% below the capacity required by the evaporator the unit would run almost continuously, pull down times would be extended, total power consumption would be

increased, and the system efficiency would be reduced to a stage where proper chilling or freezing could not be achieved. If the imbalance was reversed and the unit was 10% oversized, separation of the solute could take place and ice could form around the evaporator coils insulating them and dramatically reducing the heat exchange rate to the stage where proper chilling again would not be possible.

2) Evaporator coil capacity and efficiency

(Discussed above)

3) Solute temperature

It is necessary to raise or lower the solute temperature with different product and chilling/freezing requirements. This must be kept in balance with the solute circulation ratio.

4) Solute circulation ratio

This circulation ratio is basically controlled as a balance to the solute temperature. In an example where a whole gutted fish of 3.75 kg is to be frozen -22°C solute is required to be circulated at a rate of 6 changes/minute across the evaporator coil, this balance will vary with packaging type, e.g. glass, plastic, cellophane, or solute direct to product, of if the pack is vacuumed or loose packaged.

5) Solute composition percentages

As the wetting ability of solute changes with composition and temperature the heat transfer rate will change accordingly. This rate is more rapid at lesser percentages of glycol so it is desirous to keep glycol concentration down as low as practically possible. In the case where a solute temperature of -10°C is required for a particular application it is better to reduce the glycol concentration to suit that operating temperature and thus provide a better heat exchange rate (refrigerant to product). This not only reduces the cost of the solute but enhances the

efficiency of the system.

6) Duration of product immersion

This depends on the temperature of the finished product requirements. Timers are fitted to the machine to indicate duration of immersion and can be pre-adjusted to suit each application.

The above criteria will need to be varied with differing product. E.g. high solute temperature/longer immersion time/lesser circulation ratio/etc.

Even in the case where a customer may need a specific requirement with a common product, the balance criteria can be re-calculated to provide the required result.

Example

In prototype apparatus a head on, gutted, whole 3.75 kg Atlantic Salmon was tested.

Total chilling to +2 degrees centigrade core temperature was reached in 25 minutes.

Total freezing to -2 degrees centigrade core temperature was reached in 38 minutes.

This was achieved with 325 litres of solute at -22 degrees centigrade.

Solute composition percentages of:

50% Propylene Glycol

49% H_2O

1% Wetting Agent in the form of a non-foaming detergent with additives

All of the above compounds were of food grade quality for obvious reasons.

Food dyes were added intermittently to the solute during tests to establish the path and velocity of the solute and to determine that all sections of the fish carcass were being chilled equally. Circulation rate was adjusted by altering the speed of the circulating fan motors until satisfactory coverage was attained. The speed of circulation

would need to be reviewed with variations in type, size or configuration of the product.

An electrical control system is fitted to:

1) Cycle agitator motors, at required speed.

2) Cycle compressors in stages (to lessen start up current draw).

3) Control temperature of solute.

4) Operate a series of indicator lights (to denote equipment mode).

5) Indicate solute temperature by means of a digital thermometer.

The circulation motors 31 have been specifically designed for the apparatus. These motors are submersed in the solute and are designed to operate on low voltage so as to eliminate the chances of insulation breakdown, earth leakages or electrical shocks. They are a brushless drive speed variant and bi-directional to facilitate alternate counter rotating circulating fans which eliminates cavitation as can be experienced when using continuous rotating circulators. These motors 31 are extremely robust and operate in the solute at temperatures down to -30 degrees centigrade.

The apparatus includes sensors 7 and 8 which control thermostats and a digital temperature sensor 9. A control panel (not shown) includes switching means to select and control operating temperatures - time of immersion and solute flow parameters.

Apparatus of the kind described above is designed to be built in a variety of sizes. In a small scale unit of the kind illustrated in Figures 1 and 2, the bath would measure 1 metre by 1 metre with solute depth of 500 mm. On a larger scale a bath of 6 metres by 1 metre with solute depth of 1 metre is envisaged.

In larger applications an overhead hook style conveyor

belt would be incorporated. The conveyor 60 is illustrated schematically in Figures 1 and 2. The conveyor would be speed controlled to control rate of passage through the solute to enable the proper chilling of varying sized product without, as in the case of fish, overchilling the smaller bodies or underchilling the larger ones. The conveyor can be speed regulated as a whole or can be split into several sections, each running at a pre-set rate.

The apparatus described above is particularly designed to rapidly chill foodstuffs that include fish such as prawns, yabbies, crayfish, skinfish, scalefish, mussels, scallops, squids, octopus; most types of food; most types of vegetables; most types of meat; most types of beverages and most types of processed food products. It is understood that the foodstuffs could be raw, cooked, whole, filleted Or even pureed.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of rapidly chilling or freezing foodstuff in an open bath containing a liquid that is capable of being chilled, the liquid containing a suitable wetting agent, the method comprising the steps of:

a) selecting a temperature for chilling a liquid,

b) cooling the liquid to the selected temperature,

c) selecting a rate of flow of chilled liquid,

d) varying the speed of at least one electrically driven fan to ensure flow of liquid at the selected speed,

e) selecting the time of immersion,

f) immersing the foodstuff in the flow of chilled liquid at the selected speed and temperature, and

g) removing the chilled/frozen foodstuff from the flow of chilled liquid after expiry of the preselected immersion time.

2. The method according to Claim 1 wherein the rate of flow of chilled liquid and the temperature of the chilled liquid together with the duration of foodstuff immersion are controlled and varied to suit particular applications.

3. The method according to either Claim 1 or 2 comprising the steps of controlling the operation of an electric motor to vary the speed of the fan, the direction of rotation of the fan being reversible.

4. The method according to any one of the preceding claims comprising the step of passing foodstuffs along a conveyor part of which allows the foodstuffs to be immersed in the bath containing the chilled liquid, the speed of the conveyor being controlled to ensure that the foodstuff is immersed for the pre-selected immersion period.

5. Apparatus for rapidly chilling or freezing foodstuff comprising an open bath arranged to contain chilled liquid containing a suitable wetting agent, refrigeration means

having chilling coils positioned in the open bath, means to immerse foodstuff into the bath, means to control the period of immersion, drive means positioned within the bath to, in use cause controlled flow of liquid around the bath and past the chilling coils.

6. Apparatus according to Claim 5 further including means to monitor and control the temperature of the chilled liquid.

7. Apparatus according to either Claim 5 or Claim 6 wherein the means to control the flow of the chilled liquid comprises at least one fan driven by a bi-directional low voltage electric motor that is arranged to be submerged within the chilled liquid, and means to control the speed of the electric motor.

8. Apparatus according to any one of Claims 5 to 7 wherein the refrigeration means includes an evaporator having evaporator coils defining very short passes to minimise pressure drop.

9. The apparatus according to Claim 8 wherein the evaporator is coupled to a compressor with a provision of frequent flood back through a metered flood accumulator.

10. The apparatus according to any one of Claims 5 to 10 wherein the bath is divided into a chilling zone that contains the chilling coils and an immersion zone into which the foodstuff is to be immersed, the zones being interconnected and separated by a baffle.

11. The apparatus according to Claim 10 wherein a pair of fans are positioned in the immersion zone adjacent the chilling zone, the fans being driven by electric motors that are arranged to be immersed in the liquid contained, in use, in the chilling zone.

12. Apparatus according to any one of Claims 5 to 11 wherein the refrigeration means is positioned directly beneath the open bath and is directly coupled to the chilling coils.

13. Apparatus according to any one of Claims 5 to 12 wherein the refrigeration means is positioned away from the open bath but in direct fluid communication with the chilling coils.

14. The apparatus according to any one of Claims 5 to 13 wherein the bath is constructed of stainless steel and is clad in a suitable insulation.

15. Apparatus according to any one of Claims 5 to 14 including an overhead conveyor arranged to transport foodstuffs whereby the foodstuffs are immersed in the open bath for a predetermined period on each pass of the conveyor.

16. Apparatus according to any one of Claims 5 to 15 wherein the chilled liquid comprises 50% polypropylene glycol, 49% water, and 1% of a wetting agent in the form of a non-foaming detergent with additives.

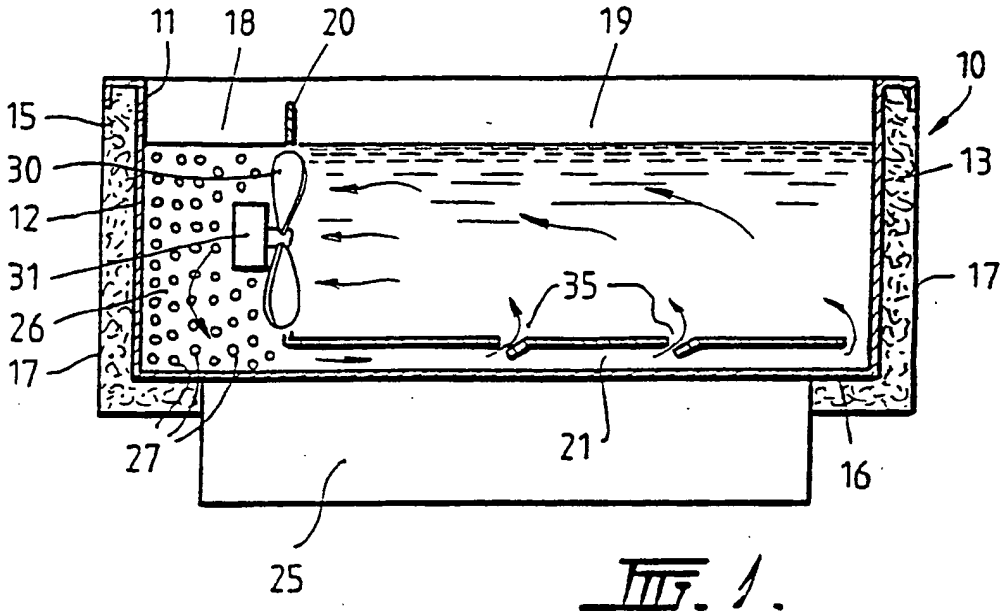


FIG. 1.

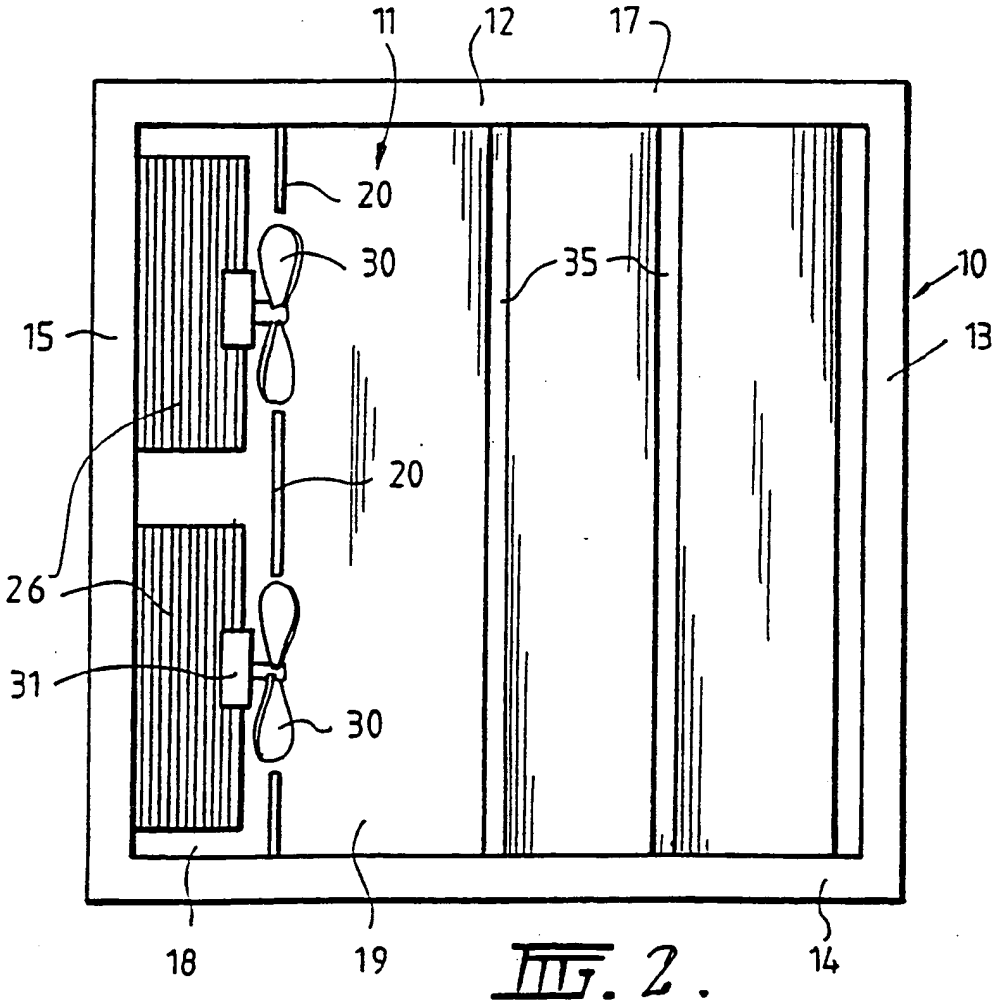
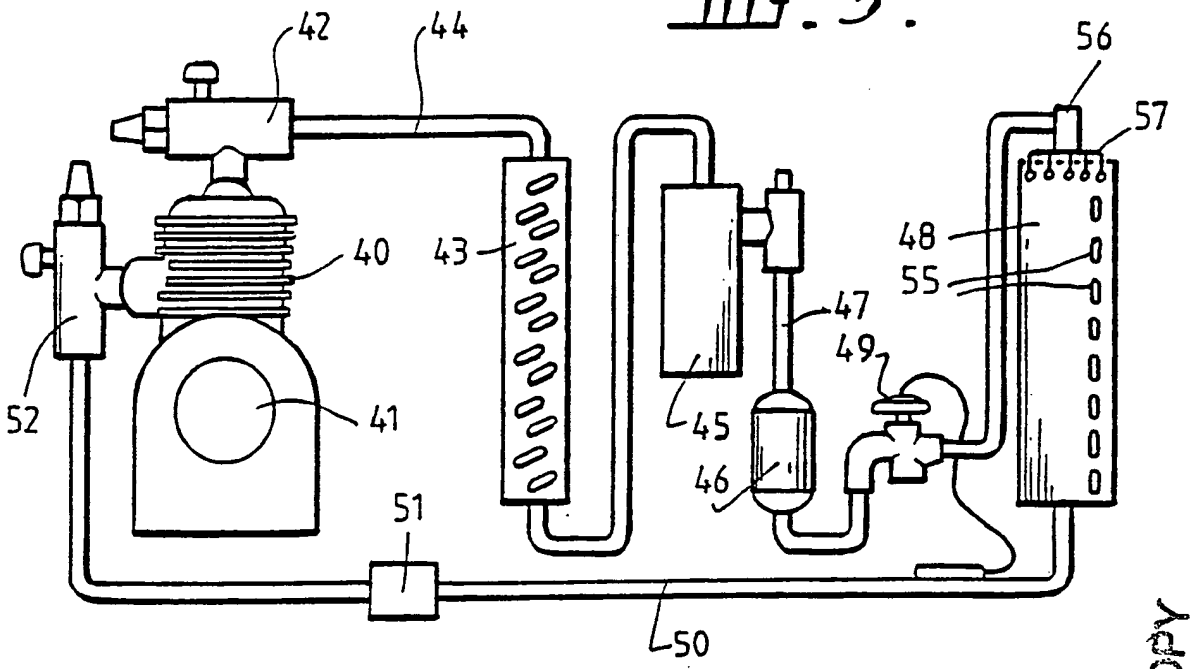


FIG. 2.

FIG. 3.



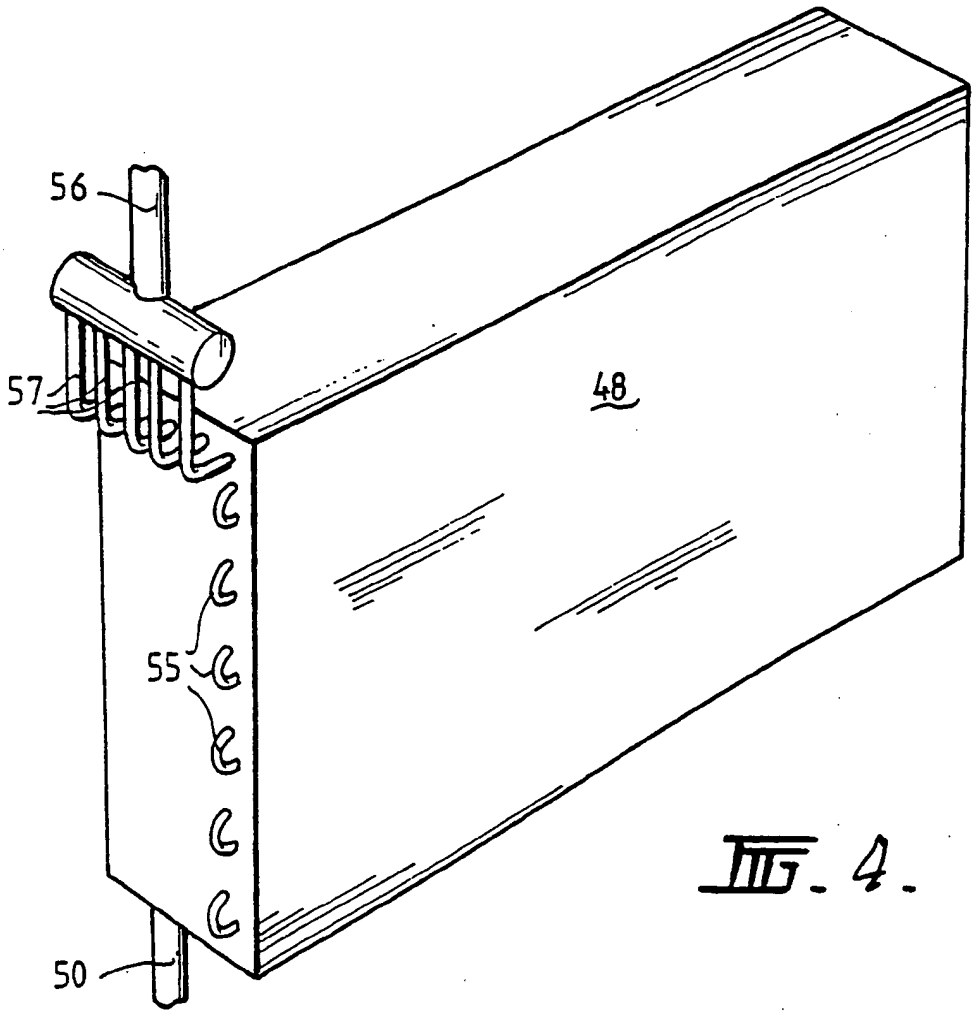


FIG. 4.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU92/00269

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl.[5] A23L 3/375, A23B 4/09, F25D 11/00, 17/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC A23L 3/37, 3/36, A23B 4/09, 4/08, F25D 11/00, 17/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
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Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)
CHEMICAL ABSTRACTS: IMMERS: and FREEZ: and BATH and (FOOD: OR EDIBLE)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
	AU, B, 34818/68 (425035) (FULLERTON, Bartleigh John) 30 July 1970 (30.07.70)	
X	whole document, page 4 lines 5-22, figure 2	1-3,5-9,12-14,16
Y	whole document, page 4 lines 5-22, figure 2	4
	US, A, 4030898 (MORITA) 21 June 1977 (21.06.77)	
Y	whole document, figure 1	4

(continued)

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
14 August 1992 (14.08.92)	22 Sept 1992 (22.09.92)

Name and mailing address of the ISA/AU	Authorized officer
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	US, A, 1431328 (PIQUE, Jean Julien) 10 October 1922 (10.10.22) whole document, page 2 lines 8-25, lines 76-80, figure 1	1-15
X	AU, B, 45514/85 (575667) (SAKAI, Tadaaki) 29 January 1987 (29.01.87) page 3 lines 25-39, figure	1-3,5-10,12-14
X	AU, B, 45515/85 (573016) (SAKAI, Tadaaki) 29 January 1987 (29.01.87) page 4 line 25 - page 5 line 13, figure	1-3,5-10,12-14
X	WO, A, 91/02933 (CASSELL, Allan John) 7 March 1991 (07.03.91) whole document, page 4 lines 11-29, page 6 line 20 - page 7 line 9, figure 3	1-3,5-14,16
P, X	EP, A, 480553 (TECHNICAN COMPANY LTD) 15 April 1992 (15.04.92) whole document, page 3 line 43 - page 4 line 28, figures 1 and 6	1-3,5-9,12-14
X	AU, B, 47155/85 (596950) (CASTLETON INC) 13 March 1986 (13.03.86) Fig. 2, page 12 lines 1-7, lines 19-28, page 14 line 30 - page 15 line 1, page 16 line 29 - page 17 line 22, claim 5	1-3,5-10,12-14
X	US, A, 3004407 (MORRIS) 17 October 1961 (17.10.61) whole document, column 2 line 44 - column 3 line 54, figures 2 and 3	1-4
X	US, A, 4309449 (O'ROARK ET AL) 5 January 1982 (05.01.82) column 2 line 65 - column 3 line 12, column 4 lines 40-46	1-3

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member						
AU	34818/68						
US	4030898	JP	51062438				
US	1431328						
AU	45514/85						
AU	45515/85						
WO	9102933	AU JP	61617/90 4501308	CA	2039696	EP	439584
EP	480553	AU	620270	CA	2034680	JP	4121178
AU	47155/85	BR	8504334	EP	174170	ES	546770
US	3004407						
US	4309449						

END OF ANNEX